THE CORPUS STRIATUM.*

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THE two nodal masses of gray matter, situated within the substance of each cerebral hemisphere, have been referred to in a previous lecture as the "basal ganglia." They appear, from their situation and relation to the radiating fibres of the cerebrum, to be the naturally appointed guardians which preside over all impulses transmitted to or from the cerebral cortex. Physiological experiment seems to point clearly to an automatism in the cells of these masses (exhibited chiefly in the maintenance of equilibrium after the hemispheres have been removed), as well as to some discriminating power also over impulses which are forced to pass through them, when the hemispheres are called into action. From an anatomical stand-point, they seem to be the poles around which the nervous elements of the cerebrum gravitate; and to constitute a crown, as it were, to the fibres of the crusta and tegmentum cruris. The corpus striatum is the anterior of these two bodies; and the fibres which are associated with it (basis cruris) can be traced into the antero-lateral columns of the spinal cord, with the exception of a few that are supposed to pass to the cerebellum. It may be considered, therefore, as the probable seat of modification and reinforcement of motor impulses emanating from the cerebral cortex. In the fresh brain, this body appears as a reddish-gray mass, situated in front of the optic thalamus in each hemisphere of the cerebrum; with its large extremity directed forward, and gradually tapering as it is prolonged toward the posterior lobes of the brain. It is abundantly supplied with capillary vessels, which circulate within its substance; and the extreme softness and friability of the mass are largely due to this fact. We know, clinically, that the larger proportion of extravasations of blood within the cerebral hemispheres affect the corpus striatum; and we may attribute the greater frequency of unilateral paralysis of motion, as compared with those of sensation, possibly to this abundance of vessels and the non-resistant character of the surrounding brain-substance.

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The caudate and lenticular nuclei become fused, however, both anteriorly and posteriorly. In front, the caput dips downward toward the region of the base of the brain, and becomes fused with the third division of the lenticular nucleus (the "olfactory district" of Gratiolet); behind, the cauda becomes joined to the temporal process of the third member of the lenticular nucleus (*pedunculus nuclei lenticularis*), near to the amygdala.

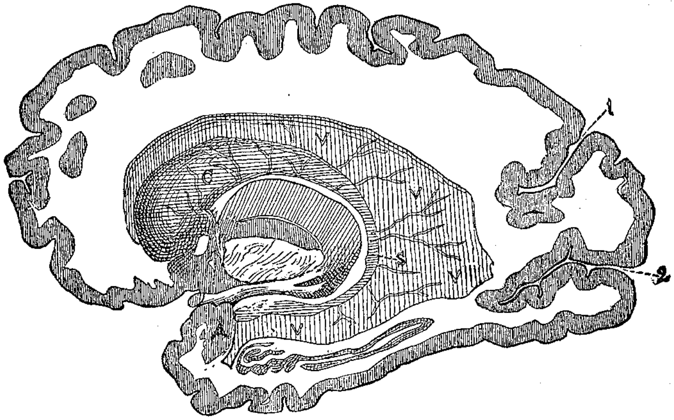

FIG. 1.—Antero-posterior vertical section of the right hemisphere, showing cavity of the lateral ventricle (after Dalton).

C, corpus striatum; *S*, surcingle of same; *V*, ventricle; *A*, amygdala; 1, internal parieto-occipital fissure; 2, calcarine fissure.

The entire mass of the corpus striatum, when viewed after the removal of the hemispheres by a horizontal cut made above the level of the basal ganglia, presents an ovoid pyriform appearance; the larger extremity being directed toward the frontal lobe, and the tapering end investing the optic thalamus (which lies behind it) as a layer of reddish-gray matter of steadily diminishing thickness. This "tail-like" prolongation (cauda) has been lately described by Dalton,[1] who has investigated its peculiarities, as forming a complete "surcingle" to the thalamus; so that vertico-transverse sections of the hemisphere of the cerebrum, made to include the thalamus, reveal two cuts of the caudate portion, an upper or ventricular portion, and a lower portion which is perceived in the region of the gyrus hippocampus (amygdala). Such a section shows, moreover, that the so-called "internal capsule" of the cerebrum divides the corpus striatum into two distinct parts; one of which has this tail-like prolongation and projects into the lateral ventricle (the caudate nucleus, or ventricular portion), while the other is shaped somewhat like a section of a lens, and lies buried within the substance of the hemisphere (the lenticular nucleus, or extra-ventricular portion).[2]

Structurally considered, the corpus striatum seems to be composed of nerve-cells of two varieties: one being of large size with many processes, and the other of small size and multipolar.[3] The small cells predominate over the large in point of numbers. It seems probable that the fibres of the spinal cord arise from one set of cells, and those destined to go to the cerebellum from the other (Luys); but this statement is, as yet, somewhat conjectural, although Meynert believes that it is supported by anatomical research.

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[1] Gratiolet, Hirschfield, and Todd confirm this view.

[2] The reader is referred to the diagrams incorporated.

[3] These cells vary from 30 μ to 15 μ in length. $\mu = \frac{1}{1000}$ millemetre.

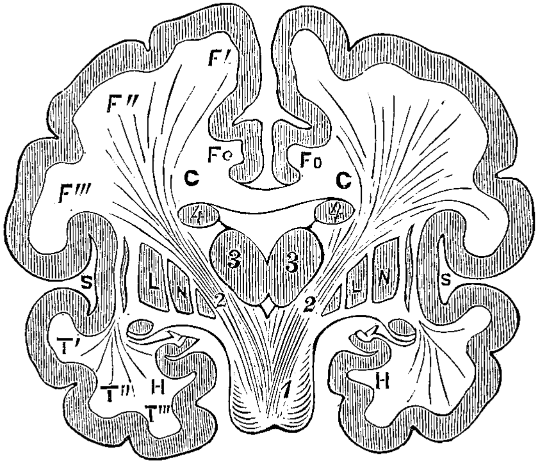

Fig. 2.—A diagram of the brain in transverse vertical section (after Dalton). 1, crus cerebri; 2, internal capsule; 3, optic thalamus, 4, caudate nucleus; *C*, *C*, corpus callosum; *L*, *N*, lenticular nucleus; *S*, fissure of Sylvius; *Fo*, gyrus fornicatus; *F'*, *F''*, *F'''*, first, second, and third frontal convolutions; *T'*, *T''*, *T'''*, temporal convolutions; *H*, gyrus hippocampi.

The nucleus lenticularis is shaped somewhat like a wedge, its base being directed toward the frontal lobe and the island of Reil, while its point passes into the crusta (basis cruris of Meynert), and terminates posteriorly in a jagged, thin edge. If a section through its substance be examined, the microscope will show the existence of two sets of nerve-fibres, viz.: one, whose direction corresponds to the general course of its longest axis, or from base to apex; and a second, which runs parallel with its curved base.[1] The second set divides the ganglion into three distinct members (Glieder), the external being the thicker and larger, while the two inner are the richer in medullary fibres, which gives them the name of "globus pallidus." (See diagram, fig. 3).

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[1] The fibres of the lenticular nucleus which run parallel with the curved base of the wedge, separate the three divisions of the ganglion. The extra-ventricular half of the corpus striatum must be regarded as connected especially with the fibres which arise from the island of Reil and other parts in the vicinity of the walls of the Sylvian fissure. Its form suggests that the frontal and parietal lobes furnish by far the greater number of its fibres, as contrasted with the temporal and occipital. It is worthy of remark, that the fibres which pass through this ganglion do not take a direct course, but describe complicated spiral lines.

Within the substance of the corpus striatum (at its inferior and internal portion), there exists a mass of yellowish colored matter to which the name "*yellow nucleus*" has been applied by Luys. In it, the smaller cells of this ganglion are very abundant, and the processes given off from them are of extreme tenuity. There are some grounds for the theory that these smaller cells represent the cerebellar elements of the ganglion, while the large cells are connected with the motor nerves of the projection tract.

Meynert has recognized this collection of nerve-cells, which presents, to his mind, most striking peculiarities. He locates it in the inferior region of the caudate nucleus, extending from a point just above the lamina perforata, anterior to the neighborhood of the anterior commissure. The peculiar anatomical features of this mass are stated by this author to consist (1) of an agglomeration of small nerve-cells into piles, which are distinctly circumscribed; and (2) of very small granules (6 μ in diameter) packed into close masses, and distinctly isolated. This latter element is not found elsewhere in the collective cerebral ganglia, and is believed by Meynert to indicate a structural relationship between the caudate nucleus and the olfactory lobe.

We find other cells in the corpus striatum, in addition to the two varieties of nerve elements already described, those of the neuroglia; but they are of little if any importance from a physiological or clinical point of view.

The nerve-fibres associated with the corpus striatum may be divided into two groups, afferent and efferent. The afferent set comprise (1) those which spring from the cortex and enter the substance of the ganglion; and (2) some fibres connected with the superior peduncles of the cerebellum, which are capable of being traced to it.[1] The efferent set

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[1] The afferent fibres of the caudate nucleus may be traced as five distinct groups, as follows:

comprise those fasciculi which help to form the cerebral peduncle (crus cerebri) and which are dispersed, after having passed through the pons Varolii, chiefly in the different segments of the spinal cord.[1]

Let us now consider certain points in the arrangement and probable function of these groups of fibres.

The afferent fibres which spring from the cortex and unite with the nerve-cells of the corpus striatum may be designated as the "cortico-striate" group. They appear to spring chiefly from the *psychic* (?) and *motor regions* of the cortex; hence we are apparently warranted in attributing to the corpus striatum some special association with these two functions. This view is, moreover, sustained by the fact that the efferent fibres of this ganglion are lodged principally in the motor paths of the projection system.[2]

The experiments of Fritsch and Hitzig have demonstrated that weak galvanic currents (when applied to certain regions of the cortex apparently connected with the corpus striatum by radiating fibres) produce muscular movements in special regions of the body; and they were thus enabled to create, at will, motions of the eye, tongue, mouth, neck, and limbs. Bartholow has demonstrated the same physiological result in the brain of a man, in whom the top of the skull had

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1. Fibres which spring from the entire length of the arch of the cerebral hemisphere (*corona radiata*).
2. A bundle of fibres springing from the cortex of the temporal lobe to the most anterior part of the caudate nucleus, following a curved course along the inner border of that ganglion (*stria cornea*).
3. Fibres which arise from the cortex of the olfactory lobe and pass to the corpus striatum.
4. Fibres which unite the cortical substance of the septum lucidum with the inferior region of the corpus striatum (*pedunculus septi lucidi*).
5. Fibres of the cerebellum, which reach the cerebrum as described above.

The *upper* border of the caudate nucleus of the corpus striatum, which is, at the same time its *outer*, seems to be the pole toward which the afferent fibres of the ganglion centre, with the exception of the stria cornea. The *lower* or *inner border* acts as the peripheric pole, from which its efferent fibres emerge.

[1] Some of the efferent fibres of the corpus striatum probably go to the cerebellum.

[2] A term first brought into general use among neurologists by Meynert.

become destroyed by disease. Both Bourdon and Luys have discovered an atrophy of cortical motor centres (as the result of loss of its function) in subjects deprived of a limb by amputation. In spite of these facts, however, we are still unable to state positively that all the fibres which radiate from the motor centres of the cortex are directly united with the nerve-cells found in the corpus striatum; since one bundle (the so-called "internal capsule"),[1] seems to pass directly through the ganglion without meeting any interrupting cell elements in its passage. Whether this is actually the case, or only an apparent one, it is impossible to determine from our present knowledge.

Among the afferent fibres of the corpus striatum, I have mentioned certain terminal expansions of the superior peduncles of the cerebellum. It seems to be now accepted, by most observers, that the fibres of these peduncles first decussate in the median line, and afterward become associated in the formation of two masses of a reddish color (red nuclei of Stilling), from which may be traced numerous filaments of a yellowish color, that, after extensive interlacement with each other, are prolonged to the yellow nucleus of the corpus striatum. An attractive theory has been advanced by Luys, that these delicate fibrils are the wires which carry the continuous currents of electric force, which overflow from the cerebellum to the corpus striatum, and thus constantly charge the cells of that body, which are liable to become exhausted by the controlling influence exerted by them over motor impulses transmitted from the cortex of the cerebrum. Physiological experiment points strongly to cerebellar innervation of motor acts, since disturbances in co-ordination of movement are produced by disease of the cerebellum, and motor acts appear to be weakened: phenomena of the greatest importance, as tending to confirm the view taken regarding the foci of motor innervation.

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[1] The so-called "internal capsule" separates the two parts of the corpus striatum, in front, and the lenticular nucleus from the optic thalamus, posteriorly. It extends into the crus as a part of the second projection system, the "basis cruris cerebri." Within the crus, those fibres which are connected with the tail of the intra-ventricular portion of the corpus striatum are described by Meynert as pursuing a somewhat peculiar course. They seem to appear to emerge from among the external bundles, and to disappear again among the internal fasciculi of the crus. To reach this portion of the crus, they are forced to cross the intermediate bundles.

The corpus striatum, like the optic thalamus, may be considered, therefore, as a territory in which cerebral, cerebellar, and spinal activities are brought into intimate communication. It acts as a halting place for voluntary motor impulses emitted from the cerebral cortex. It enables these impulses to become modified and possibly reinforced by currents derived from the cerebellum; and, by its efferent fibres, it transmits centrifugal motor impulses along the projection system to different groups of cells within the spinal gray matter, whose individual functions they tend to evoke.

To sum up, this ganglion probably acts as a condenser and modifier of all motor acts which are the result of volition; and manifests, through the agency of its satellites (the cells of the anterior horns of the gray matter of the spinal cord), the outward expressions of our personality. Without the influence of the cerebral hemispheres, it is also capable, by means of cerebellar innervation, of governing all the complex muscular movements required in maintaining equilibrium (coördinated movements). Finally, it may be presumed to possess the power of analysis of cerebral and cerebellar currents received simultaneously, and of materializing them by the intervention of its nerve-cells, projecting them in a new form, amplified and incorporated with the requirements of the general organism.

Experiments made upon the caudate and lenticular nuclei can hardly be said to have afforded results which can be made the basis for positive deductions respecting the

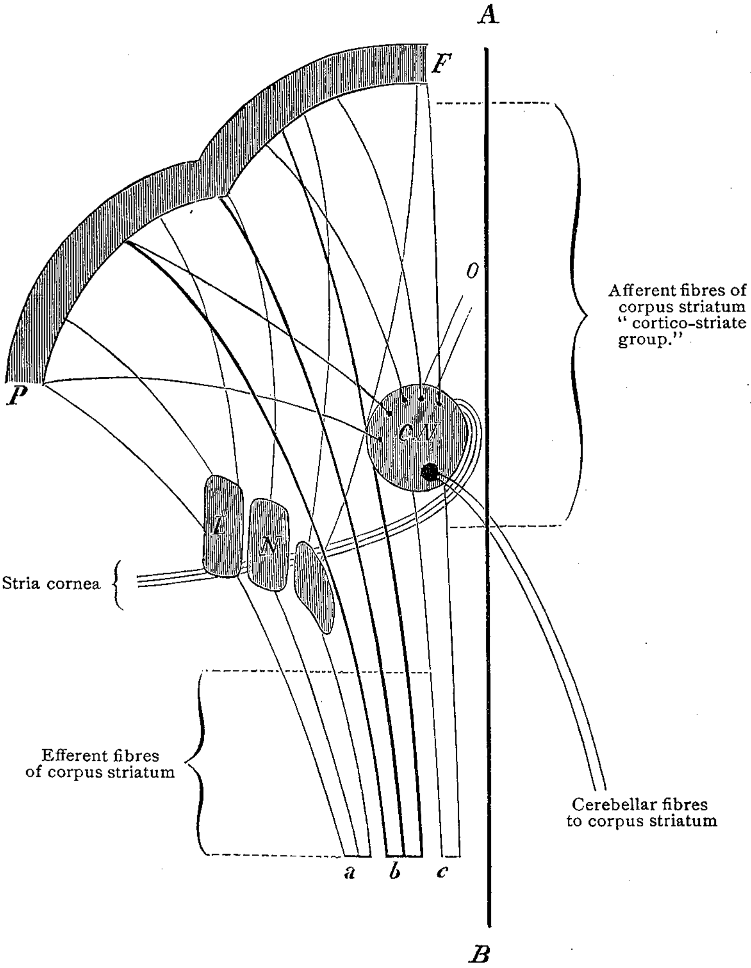
A
F
P
O
C.N.
L
N
Afferent fibres of corpus striatum "cortico-striate group."
Stria cornea
Efferent fibres of corpus striatum
Cerebellar fibres to corpus striatum
a
b
c
B

Fig. 3.—A diagram designed to show the afferent and efferent fibres of the corpus striatum. *C, N,* "caudate nucleus," or ventricular portion of corpus striatum; *L, N,* "lenticular nucleus," or extra-ventricular portion of corpus striatum; *A—B,* median line, separating cerebral hemispheres; *P—F,* psycho-motor regions of the cortex; *a,* peduncular fibres connected with *L, N*; *b,* fibres of the so-called "internal capsule"; *c,* fibres connected with *C, N*; *O,* olfactory fibres.

functions of each. Nothnagel employed injections of chromic acid into the substance of each, and also destroyed them by means of an instrument devised for that purpose, but he made no positive conclusions save that the lenticular nucleus seemed to have a more decided influence upon motion than the caudate nucleus, when both sides were simultaneously destroyed.

Some observers claim to have removed the entire ganglion without any marked disturbance of sensory or motor phenomena.

In no instance, to my knowledge, has the destruction of these nuclei produced psychic effects. When akinesia (loss of movement) has been thus artificially produced, it seems to be absolutely confined to the opposite side of the body. In cases of extreme rarity, lesions have been shown clinically to have resulted in a paralysis of motion of the same side ; but Flechsig has helped us to properly interpret these cases, as they afford evidence of an individual peculiarity in the relative number of decussating and direct pyramidal fibres. Ferrier has produced convulsive movements of the opposite side of the body by faradism of the corpus striatum, and Carville and Duret's observations seem to be in full accord, thus sustaining the theoretical view first advanced by Carpenter and Todd, as to an exclusively motor function in this ganglion. Burdon–Sanderson also has produced *localized* movements by electric stimulation of the white matter of the brain in the region of the corpus striatum.

It would be rash to draw any conclusions of a positive nature in the face of such a conflicting mass of experimental and clinical evidence ; but it cannot be disputed that those who support the doctrine that the fibres of the internal capsule are the direct paths for motor and sensory impulses (the anterior two thirds being motor, and the posterior third sensory, in function), and that all effects of experiment upon or disease of the corpus striatum are the result of *pressure upon this tract,* have, in the light of our present knowledge, the most plausible theory. In what way this path of conduction is brought in direct or indirect dependence upon the cell elements of the nodal masses, with which it bears so intimate a relation, it is impossible to state positively; but it cannot be denied that it seems to have the power of isolated conduction, in spite of any connections with ganglion cells, which may yet be proven to exist.